University of Technology Sydney

Faculty of Engineering and Information Technology

Design and Control of a Novel Uninterrupted Dual Input Powertrain System for Electric Vehicles

A thesis submitted for degree of

Doctor of Philosophy

Jiejunyi LIANG

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Certificate of Original Authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abbreviations

HEV - Hybrid Electric Vehicle

PHEV - Plug-in Hybrids Electric Vehicles

EV - Electric Vehicle

FCV - Fuel Cell Vehicles

CVT - Continuously Variable Transmission

DCT - Dual Clutch Transmission

EMS - Energy Management Strategies

ICE - Internal Combustion Engine

AMT - Automated Manual Transmission

DP - Dynamic Programming

SA - Simulated Annealing

GA - Genetic Algorithms

PMP - Pontryagin's Minimum Principle

PSC - Power Sharing Control

THS - Toyota Hybrid System

ECVT - Electronic Continuously Variable Transmission

CHS - China Hybrid System

IVT - Infinitely Variable Transmission

FHS - Ford Hybrid System

UMST - Uninterrupted Multi-Speed Transmission

RTCS - Real-Time Control Stragety

SOC - State of Charge

FOC - Field Oriented Control

DTC - Direct Torque Control

MPTC - Model Predictive Torque Control

MPFC - Model Predictive Flux Control

MT - Manual Transmission

AT - Automatic Transmission

CLAMT - Clutchless Automated Manual Transmission

LA-92 - Los Angeles 92 / Unified Cycle Driving Schedule

HWFET- Highway Fuel Economic Test

Abstract

The automotive powertrain is one of the most important subsystems of any vehicle whose major function is to convert the stored energy to kinetic energy and deliver it as tractive load to the road. In order to reduce the harmful emissions and the dependence on fossil fuels, the development. The new technology will improve the overall efficiency, the drivability and the driving comfort, and reduce the tailpipe emissions. However, the inclusion of electric machines alone does not guarantee these improvements, proper transmission structure design and adequate control strategy should be designed to fully exploit the potential of the whole system, thereby maximizing the benefits to end users.

In order to achieve the aforesaid benefits of electric vehicle, a novel dual input clutchless transmission configuration is proposed which consists of an automated manual transmission (AMT) and a fixed gear pair. It has the merits of low manufacturing cost, robustness and easy implementation. With the proposed gear shift control strategy, the novel configuration could eliminate the torque interruption of conventional AMT systems, improving the drivability and driving comfort.

To fully exploit the efficiency improvements of the proposed system, a real time power sharing control strategy is proposed to balance the load distribution between the two motors. By adequately choosing the gear position and distributing the power demand, the overall efficiency could be improved by more than 10%.

The proposed power sharing strategy has the disadvantage encountered by many other energy-oriented energy management strategies which is high gear shifting frequency. To keep a high overall efficiency and at the same time significantly reduce the shift frequency, a shifting stabilizer is proposed and embedded in to the control strategy.

At last, a modified hybrid configuration based on the proposed concept is developed for mining trucks. The hybrid system could satisfy the specific requirements of mining trucks and present high overall efficiency and drivability.

To evaluate the effectiveness of the proposed approaches, various detail mathematical models have been built and tested in sets of driving conditions which could reflect the practical implementations.